CLAIMS

1. A method of field detection comprising:

providing a gradiometer in a field, the gradiometer having at least first and second field vector sensors connected in a differencing arrangement; and

controllably altering a position of the at least first and second field vector sensors relative to the field during operation of the gradiometer.

2. The method of claim 1 wherein the at least first and second field vector sensors of the gradiometer are substantially axially aligned, such that the gradiometer is an axial gradiometer.

3. The method of claim 1 or claim 2 wherein the step of controllably altering the position of the at least first and second field vector sensors is performed by rotating the at least first and second field vector sensors about an axis of rotation.

4. The method of claim 3 wherein the step of controllably altering the position of the at least first and second field vector sensors is performed by rotating the at least first and second field vector sensors continuously during operation of the gradiometer.

5. The method of claim 4, further comprising the step of providing a motor for driving the gradiometer at a substantially constant revolutional velocity about the axis of rotation.

6. The method of claim 3 wherein the step of controllably altering the position of the at least first and second field vector sensors is performed by rotating the at least first and second field vectors piecewise about an axis of rotation.

7. The method of claim 3 when dependent on claim 2 or any one of claims 4 to 6 when dependent on claims 2 and 3, wherein the axis of rotation is positioned substantially perpendicular to the axial alignment of the first and second field vector sensors.

8. The method of claim 7 wherein the axis of rotation is positioned substantially between the first and second field vector sensors.

9. The method of claim 7 or claim 8, wherein the axis of rotation is positioned substantially equidistant from the first and second field vector sensors.

10. The method of any one of the preceding claims wherein the gradiometer is an axial magnetic gradiometer.

11. The method of claim 10 wherein the field vector sensors of the axial magnetic gradiometer are SQUIDs.

12. The method of claim 10 wherein the field vector sensors of the axial magnetic gradiometer are flux gates.

13. The method of claim 10 wherein the field vector sensors of the axial magnetic gradiometer are superconducting pick-up loops.

14. The method of any one of claims 10 to 13 wherein the sensitivity vectors of the field vector sensors lie substantially in a nominal x-y plane.

15. The method of claim 14 wherein the axial magnetic gradiometer is rotated about a nominal z-axis perpendicular to the x-y plane.

16. The method of any one of claims 10 to 15 further comprising the step of retrieving information relating to the magnetic field from the axial magnetic gradiometer as its position is controllably altered.

17. The method of claim 16 wherein the information relating to the magnetic field comprises the g_{xy} component and linear combinations of the values of the g_{xx} and g_{yy} components of a field gradient tensor, in addition to information about the B_x and B_y field components.

18. The method of claim 16 or claim 17 wherein the step of retrieving information relating to the magnetic field further comprises transforming a received signal from the field vector sensors into the Fourier domain in order to retrieve the information relating to the magnetic field.

19. The method of any one of the preceding claims further comprising the steps of:

providing second and third gradiometers, each of the gradiometers having at least first and second axially aligned field vector sensors connected in a differencing arrangement;

positioning the gradiometers such that an axis of each gradiometer is not parallel to an axis of any other of the gradiometers; and

controllably altering a position of the at least first and second field vector sensors of each gradiometer relative to the field during operation of that gradiometer.

20. A field detection device comprising:

a gradiometer, the gradiometer having at least first and second field vector sensors connected in a differencing arrangement; and

means for controllably altering the position of the at least first and second field vector sensors relative to a field during operation of the gradiometer.

21. The device of claim 20, wherein the at least first and second field vector sensors of the gradiometer are substantially axially aligned, such that the gradiometer is an axial gradiometer

22. The device of claim 20 or claim 21, wherein the means for controllably altering the position of the at least first and second field vector sensors comprises means for rotating the at least first and second field vector sensors about an axis of rotation.

23. The device of claim 22 wherein the means for rotating the at least first and second field vector sensors about the axis of rotation is operable to rotate the at least first and second field vector sensors continuously during operation of the gradiometer.

24. The device of claim 23 wherein the means for rotating is a motor operable to drive the gradiometer at a substantially constant revolutional velocity about the axis of rotation.

25. The device of claim 22, wherein the means for rotating the at least first and second field vector sensors about the axis of rotation is operable to rotate the gradiometer piecewise about the axis of rotation.

26. The device of claim 22 when dependent on claim 21 or any one of claims 23 to 25 when dependent on claims 21 and 22, wherein the axis of rotation is positioned substantially perpendicular to the co-axial first and second field vectors.

27. The device of claim 26 wherein the axis of rotation is positioned substantially between the first and second field vector sensors.

28. The device of claim 26 or claim 27 wherein the axis of rotation is positioned substantially equidistant from the first and second field vector sensors.

29. The device of any one of claims 20 to 18, wherein the gradiometer is an axial gradiometer.

30. The device of claim 29, wherein the field vector sensors of the magnetic axial gradiometer are SQUIDs.

31. The device of claim 29, wherein the field vector sensors of the magnetic axial gradiometer are flux gates.

32. The device of claim 29, wherein the field vector sensors of the magnetic axial gradiometer are superconducting pick-up loops.

33. The device of any one of claims 29 to 32 wherein the sensitivity vectors of the field vector sensors lie substantially in a nominal x-y plane.

34. The device of claim 33 wherein the means for controllably altering the position of the at least first and second field vector sensors comprises means for rotating the at least first and second field vector sensors about a nominal z-axis perpendicular to the x-y plane.

35. The device of any one of claims 29 to 34 further comprising means for retrieving information relating to the magnetic field from the axial magnetic gradiometer as its position is controllably altered.

36. The device of claim 35 wherein the information relating to the magnetic field comprises the g_{xy} component and linear combinations of the values of the g_{xx} and g_{yy} components of a field gradient tensor, in addition to information about the B_x and B_y field components.

37. The device of claim 35 or claim 36 further comprising means for transforming a received signal from the field vector sensors into the Fourier domain in order to retrieve the information relating to the magnetic field.

38. The device of any one of claims 20 to 37, further comprising:

second and third gradiometers, each of the gradiometers having at least first and second field vector sensors connected in a differencing arrangement, the gradiometers being positioned such that an axis of each gradiometer is not parallel to an axis of any other of the gradiometers; and

means for controllably altering a position of the at least first and second field vector sensors of each gradiometer relative to the field during operation of that gradiometer.

39. A method of obtaining a complete magnetic gradient tensor of a magnetic field, the method comprising:

providing at least three axial gradiometers in the magnetic field such that an axis of each axial gradiometer is not parallel to an axis of any other one of the at least three gradiometers; and

controllably altering a position of each of the at least three gradiometers relative to the magnetic field during operation of the gradiometer.

40. The method of claim 39 wherein the step of controllably altering comprises rotating each of the at least three axial gradiometers about a respective axis of rotation of that gradiometer.

41. The method of claim 40 wherein the axis of rotation of each gradiometer is not parallel to an axis of rotation of any other one of the at least three gradiometers.

42. The method of claim 41 or claim 42 wherein the at least three gradiometers are rotated at a substantially constant velocity about their respective axes of rotation.

43. The method of claim 42 further comprising the step of transforming obtained data to the Fourier domain.

44. The method of claim 43 further comprising the step of distinguishing field gradient information from field information in the Fourier domain.

45. The method of claim 43 or claim 44 further comprising distinguishing information about the g_{xy} component of the gradient tensor from information due to the diagonal gradient components, even at the same frequency.

46. The method of any one of claims 43 to 45 wherein the Fourier transform is performed by a fast Fourier transform algorithm.

47. The method of any one of claims 43 to 45 wherein the Fourier transform is performed by a simple discrete implementation via a coarse sampling of a discrete number of data points per cycle of the rotation.

48. The method of claim 47 wherein eight data points are sampled.

49. The method of claim 47 or claim 48 wherein the data points are positioned equally around the 360 degree rotation.

50. The method of any one of claims 42 to 49 further comprising the step of applying a least-squares best-fit solution to obtained data.

51. The method of any one of claims 42 to 50 wherein DC offsets are determined and monitored to provide information about the operating conditions of the gradiometers.

52. The method of claim 51 wherein the DC offsets comprise one or both of: low frequency drift in at least one field vector sensor of the at least three gradiometers; and the fixed offset of at least one field vector sensor of the at least three gradiometers.

53. The method of any one of claims 42 to 52, further comprising the step of isolating the at least three gradiometers from physical vibration occurring in the vicinity of their respective fundamental and first harmonic frequencies of rotation.

54. The method of any one of claims 42 to 53 wherein the at least three gradiometers are rotated at differing frequencies, in order to facilitate separation of their data signals in the Fourier domain.

55. A device for obtaining a complete magnetic gradient tensor of a magnetic field, the device comprising:

at least three axial gradiometers positioned such that an axis of each axial gradiometer is not parallel to an axis of any other one of the at least three gradiometers; and

means for controllably altering a position of each of the at least three gradiometers relative to the magnetic field during operation of the gradiometer.

56. The device of claim 55 wherein the means for controllably altering are means for rotating each of the at least three axial gradiometers about a respective axis of rotation of that gradiometer.

57. The device of claim 56 wherein the axis of rotation of each gradiometer is not parallel to an axis of rotation of any other one of the at least three gradiometers.

58. The device of claim 56 or claim 57, wherein the at least three gradiometers are rotated at a substantially constant velocity about their respective axes of rotation.

59. The device of claim 58, further comprising means for converting data obtained from the at least three gradiometers to the Fourier domain.

60. The method of claim 58 or claim 59 wherein the at least three gradiometers are rotated at differing frequencies, in order to facilitate separation of their data signals in the Fourier domain.

61. The device of any one of claims 56 to 60 further comprising means for applying a least-squares best fit solution to obtained data.

62. The device of any one of claims 56 to 61 further comprising means for detecting and measuring a DC offset.

63. The device of claim 62 wherein the DC offset comprises one or both of: low frequency drift in at least one field vector sensor of the at least three gradiometers; and the fixed offset of at least one field vector sensor of the at least three gradiometers.

64. The device of claim 62 or claim 63 further comprising means for determining operating conditions of one or more of the at least three gradiometers based on said detected and measured DC offset.

65. The device of any one of claims 62 to 64 wherein said means for detecting and measuring a DC offset separates the DC offset from field data and gradient data in the Fourier domain.

66. The device of any one of claims 56 to 65 further comprising means for distinguishing field gradient information from field information in the Fourier domain.

67. The device of any one of claims 56 to 66 further comprising means for distinguishing information about the g_{xy} component of the gradient tensor from information due to the diagonal gradient components, even at the same frequency.

68. The device of claim 59 wherein the Fourier transform is implemented by means of a fast Fourier transform algorithm.

69. The device of claim 59 wherein the Fourier transform is implemented by sampling discrete data points throughout each cycle of rotation.

70. The device of claim 69 wherein eight discrete data points are sampled.

71. The device of claim 69 or 70 wherein the discrete data points are equidistant throughout the cycle of rotation.

72. The device of any one of claims 56 to 71 further comprising means for isolating the at least three gradiometers from physical vibration occurring in the vicinity of their respective fundamental and first harmonic frequencies of rotation.